PROBE CALIBRATION REFERENCE
MODELS HTR-150 AND HTR-300
OPERATING AND MAINTENANCE MANUAL

KAYE
INSTRUMENTS

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MODELS HTR-150 AND HTR-300

OPERATION AND MAINTENANCE MANUAL

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TABLE OF CONTENTS

SECTION 1: GENERAL INFORMATION

- Specifications 1-1
- Applications 1-2

SECTION 2: OPERATION

- Principles of Operation 2-1
- Power Requirements 2-1
- General Operating Instructions 2-2
- HTR-150 Adjustments 2-3
  - Temperature Adjustments 2-3
  - Differential Adjustments 2-3
- HTR-300 Adjustments 2-4
  - Temperature Adjustments 2-4
  - Differential Adjustment 2-4

SECTION 3: MAINTENANCE AND TROUBLESHOOTING

- Fuses 3-1
- Preliminary Troubleshooting Procedures 3-1
- Internal Resistance Checks 3-3

SECTION 4: REPLACEMENT PARTS

- HTR Series Replacement Parts List 4-1

SECTION 5: ACCESSORY EQUIPMENT

- HTR Series Accessory Equipment List 5-1

FIGURES

- Figure 2-1: HTR-150 Vernier Setting vs Block Temperature 2-3
- Figure 2-2: HTR-300 Vernier Setting vs Block Temperature 2-4
- Figure 3-1: HTR-150 Meter Voltages vs Block Temperature 3-2
- Figure 3-2: HTR-300 Meter Voltages vs Block Temperature 3-2

TABLES

- Table 3-1: HTR Series Trouble Isolation Guide 3-3
- Table 3-2: Reference Block Resistance Values 3-4

APPENDICES

- Appendix A: HTR-150/HTR-300 Schematics A-1
- Appendix B: HTR-150/HTR-300 Component Layout B-1
- Appendix C: Model 373/374/375 Error Summaries C-1
- Appendix D: Warranty D-1

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SECTION 1

GENERAL INFORMATION

Section 1 lists the specifications for the Kaye HTR-150 and HTR-300 Probe Calibration References, identifies sources of possible HTR series calibration errors and suggests applications for the HTR series instruments.

HTR Series Specifications

Parameter	HTR-150 Specification
Overall Dimensions	Width: 22.1 cm (8.70 in.) Depth: 37.6 cm (14.81 in.) Height: 40.5 cm (15.94 in.)
Weight	14.6 Kg (32 lbs.)
Power	Standard: 105-125 VAC, 50/60 Hz 200 watts maximum Optional: 220 VAC, 50/60 Hz
Ambient Temperature	0°C to 50°C
Set Point	35°C to 150°C (95°F to 260°F) Minimum = Ambient + 3°C
Set Point Stability	±0.1°C, 30 days
6 Small Well Dimensions	Depth: 15.2 cm (6.00 in.) Inside Diameter: 7.4 mm (0.29 in.)
1 Large Well Dimensions	Depth: 15.2 cm (6.00 in.) Inside Diameter: 9.9 mm (0.39 in.)

Parameter	HTR-300 Specification
Overall Dimensions	Width: 22.1 cm (8.70 in.) Depth: 37.6 cm (14.81 in.) Height: 48.1 cm (18.94 in.)
Weight	18.2 Kg (40 lbs.)
Power	Standard: 105-125 VAC, 50/60 Hz 250 watts maximum Optional: 220 VAC, 50/60 Hz
Ambient Temperature	0°C to 50°C
Set Point	40°C to 300°C (104°F to 572°F) Minimum = Ambient + 3°C
Set Point Stability	±0.2°C, 30 days
6 Small Well Dimensions	Depth: 22.8 cm (8.96 in.) Inside Diameter: 7.4 mm (0.29 in.)
1 Large Well Dimensions	Depth: 22.8 cm (8.96 in.) Inside Diameter: 9.9 mm (0.39 in.)

NOTE

There are three sources of HTR-150 or HTR-300 calibration errors:

- RTD Monitor or thermometer calibration errors
- Probe stem conduction errors
- Non-uniform HTR-150 or HTR-300 wells

Calibrated RTD Monitors or thermometers should supply readings accurate to within ±0.05°C at specified points. Probe stem conduction errors for fully immersed standard temperature probes should never exceed ±0.04°C (HTR-150) or ±0.2°C (HTR-300). With fully inserted probes and stabilized references, HTR-150 and HTR-300 reference wells are uniform in temperature to better than ±0.02°C and ±0.2°C respectively.

Appendix C contains a detailed user's error summary analysis along with error summaries for the Kaye Models 374 and 375 Platinum Resistance Thermometers. The stated accuracies are based on an HTR-150 or HTR-300 operating at its nominal maximum temperature. The total HTR-150 and HTR-300 systems achieve an accuracy of ±0.10°C and ±0.5°C respectively. Errors for lower temperatures are approximately proportional to the difference between room temperature and the calibration temperature.

Applications

Kaye's high temperature references (HTR's) calibrate thermocouple probes from 38°C to 300°C. You can use the HTR-150 for calibrating equipment used for pyrogen testing or steam sterilization. You can use the HTR-300 for calibrating equipment used in the control of hot gas sterilization. Insert probes into the reference wells before and after use to verify their accuracy.

A calibrated RTD Monitor or thermometer determines the temperature of the HTR. Kaye's HTR's insure accurate calibration and eliminate the need for special operator training. The HTR's eliminate common technique errors often encountered when using oil baths (i.e. imersing the probes to varying depths or inadequately agitating the oil bath solution). You can effectively use these instruments both on the plant floor and in the calibration laboratory.

SECTION 2

OPERATION

Principles of Operation

The HTR series accurately calibrates sensors. The heating media include two electrically heated aluminum blocks (cylinders): the reference and guard blocks. The larger block (reference block) receives the temperature sensitive tip of the sensor. You pass the sensor tip through the guard block before inserting it into the reference block. The guard block, mounted above the reference block, maintains a slightly warmer temperature than the reference block. This minimizes longitudal temperature gradients in the reference block and suppresses sensor stem-conduction errors inherent in other calibration systems such as oil baths.

An electric resistance heater surrounds the main block. Perimeter heating helps eliminate radial temperature gradients. Sensor wells are parallel to and equidistant from the cylinder axis. Additional heaters above and below the reference block minimize vertical thermal gradients, producing extremely close well temperatures.

A platinum resistance temperature detector (RTD) senses the temperature of the zone in the aluminum reference block that houses the sensors. An RTD (PRT-3, Appendix A) forms one arm of a Wheatstone bridge. A linear operational amplifier (A2) amplifies the bridge output voltage. The operational amplifier output drives the output Darlington transistor (Q2), thereby supplying current to the heater surrounding the reference block. A rise in the block temperature causes an increase in the PRT-3 resistance. The bridge imbalance decreases, until it reaches the equilibrium temperature. The PRT-3 senses any subsequent block temperature changes, and reacts by making a corresponding change in the heater voltage.

A similar bridge circuit maintains a guard block temperature slightly higher than that of the reference block. This bridge circuit uses two, not one, RTD's and raises the differential temperature between the two blocks as the reference block temperature rises.

Power Requirements

If your line power is standard (115 VAC, 50/60 Hz), use the standard HTR series unit. However, if your line voltage is 220 VAC, Kaye will modify your HTR at the factory, enabling it to operate at the higher line voltages. A label affixed to the back of the instrument identifies the voltage range and fuse requirement. Failure to observe these ratings voids the warranty.

General Operating Instructions

Use the ON-OFF rocker switch to power up the HTR. The Main Heater and Guard Heater meters on the front panel display heater voltages.

Fill the HTR-150 reference wells with a light oil, such as mineral oil. This procedure insures accurate and repeatable calibrations. Light oil provides a good thermal coupling between the probe and the well's walls.

Operate the HTR-300 with DRY wells. Because the probes are radiantly heated, the HTR-300 requires no oil for coupling. If you use oil in these wells, the high operating temperatures cause fuming. In fact, using oil in the HTR-300 wells actually decreases total temperature stability, due to convection cells that set up within the oil-filled wells.

To maximize the instrument's effectiveness, fully immerse all probes. If the probe's geometry prohibits full immersion, insert the probe at least 11.5 cm (4 in.) for the HTR-150 to maintain its stated accuracy. The HTR-300 requires full immersion to maintain its stated accuracy. If you routinely perform calibrations, operate the references continuously to avoid unnecessary delays. It takes several hours to stabilize the calibration reference(s) after you turn the instrument(s) on. After reaching its operating temperature, it takes nominal power to keep the temperature stabilized.

Use standard mercury thermometers as reference block temperature monitors ONLY IF THE THERMOMETERS ARE CALIBRATED FOR A PARTIAL IMMERSION OF 6 INCHES. Platinum RTD's provide greater accuracy and damage less easily. You can order Platinum RTD's from Kaye Instruments. SECTION 5 describes Platinum RTD's.

Temperature Adjustments

The HTR-150 has two Temperature Control adjustments for adjusting block reference temperatures: the coarse and fine adjustment knobs. The coarse adjustment uses a 10-turn vernier for selecting an approximate temperature. Plot several points showing temperatures at different vernier settings. Then, using your plot as a reference, select a temperature. You should be able to dial in the temperature you've selected to within approximately 1.0°C.

Figure 2-1 shows the graph for an HTR-150. The shaded band represents a typical range of values for the vernier setting at various temperatures. Connect the marked points and show a typical line. Create a similar plot for each HTR-150. After each coarse adjustment, let the HTR-150 stabilize for several hours.

Make fine adjustments with the single-turn fine adjustment control knob. The fine control knob permits an adjustment of 0.5°C to either side of its center position. After each fine adjustment, let the HTR-150 stabilize for one hour.

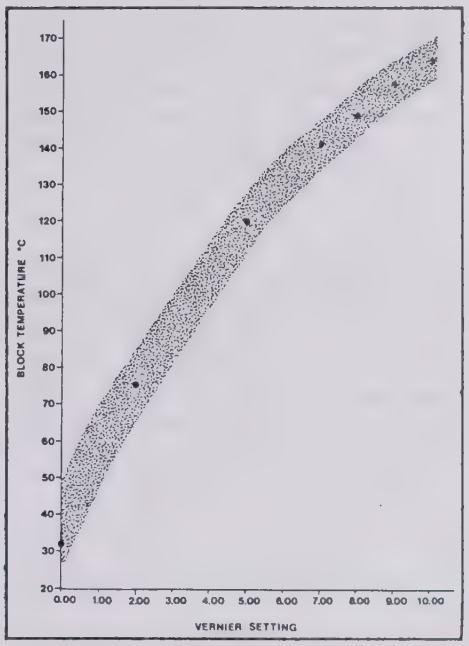

Figure 2-1: HTR-150 Vernier Setting vs Block Temperature

Differential Adjustment

Locate the third control, the differential adjustment (P-3, Appendix A) on the HTR-150's rear panel. This control adjusts the temperature difference between the guard and reference blocks. Kaye adjusts the control at the factory, so you can withdraw a fully-immersed Type 374 RTD probe 2.5 cm (1.0 in.) without perceptibly changing the probe temperature. By using a sensor, you can check this setting. Withdraw the sensor 2.5 cm (1.0 in.) and note any change in the temperature reading.

If the temperature reading increases when you withdraw the sensor, turn control P3 counter-clockwise one-quarter turn. If the temperature reading decreases, turn control P3 clockwise one-quarter turn. Once you change control P3's setting, wait at least one-half hour for the reference block temperature to stabilize before repeating the adjustment. Ultimately, you want the smallest possible temperature change when you withdraw the sensor.

Temperature Adjustments

The HTR-300 has two Temperature Control adjustments for adjusting block reference temperatures: the coarse and fine adjustment knobs. The coarse adjustment uses a 10-turn vernier for selecting an approximate temperature. Plot several points showing temperatures at different vernier settings. Then, using your plot as a reference, select a temperature. You should be able to dial in the temperature you've selected to within approximately 0.5°C.

Figure 2-2 shows the graph for an HTR-300. The shaded band represents a typical range of values for the vernier setting at various temperatures. Connect the marked points and show a typical line. Create a similar plot for each HTR-300. After each coarse adjustment, let the HTR-300 stabilize for 4 to 6 hours at full range after turning the instrument on.

The fine control knob permits an adjustment of 0.1°C to either side of its center position. After each fine adjustment, let the HTR-300 stabilize for one hour.

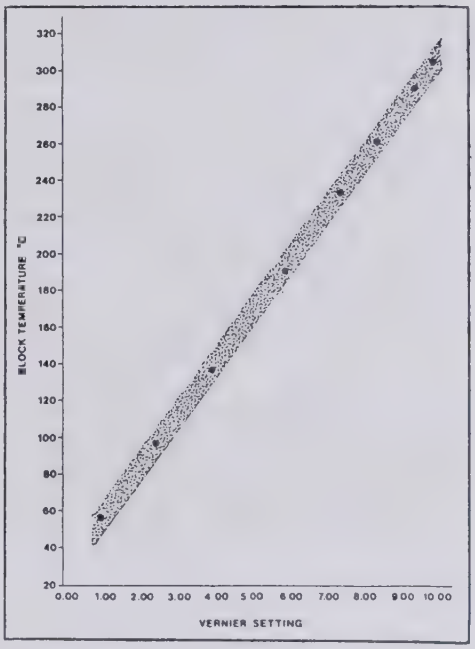

Figure 2-2: HTR-300 Vernier Setting vs Block Temperature

Differential Adjustment

Locate the third control, the differential adjustment (P-3, Appendix A) on the HTR-300's rear panel. This control adjusts the temperature difference between the guard and reference blocks. Kaye adjusts the control at the factory, so you can withdraw a fully-immersed Type 375 RTD probe 2.5 cm (1.0 in.) without perceptibly changing the probe temperature. By using a sensor, you can check this setting. Withdraw the sensor 2.5 cm (1.0 in.) and note any change in the temperature reading.

If the temperature reading increases when you withdraw the sensor, turn control P3 counter-clockwise one-quarter turn. If the temperature reading decreases, turn control P3 clockwise one-quarter turn. Once you change control P3's setting, wait at least one-half hour for the reference block temperature to stabilize before repeating the adjustment. Ultimately, you want the smallest possible temperature change when you withdraw the sensor.

SECTION 3

MAINTENANCE AND TROUBLESHOOTING

If the front panel meters show either no voltage or abnormally high (full scale) readings, this indicates an HTR system failure. You can perform selected troubleshooting procedures by referencing the HTR-150/HTR-300 schematics in Appendix A and Figures 3-1 and 3-2, which show typical meter readings at various temperatures.

The Troubleshooting section isolates problems to the main circuit board and major component level. The factory isolates problems and makes repairs at the discrete component level. Kaye Instruments maintains a complete replacement part inventory and promptly repairs any defective equipment returned to the factory.

Fuses

Each HTR has a line fuse holder in the back panel. The standard HTR-150 (115 VAC) uses a 2½ amp Slo-Blo type fuse. The Kaye-modified HTR-150 (220 VAC) uses a 1 amp Slo-Blo type fuse. The HTR-300 uses 3 amp and 1½ amp fuses for 115 VAC and 220 VAC power respectively.

Preliminary Troubleshooting Procedures

You can frequently isolate HTR series problems by following this set of preliminary troubleshooting procedures prior disassembling the instrument.

To perform the preliminary troubleshooting on an HTR-150, you:

- Compare your voltmeter panel readings at various temperatures against those shown in Figure 3-1.
- Note any voltages that are higher or lower than those in shaded portion of the graph at any temperature.
- Find the symptom and probable cause in Table 3-1.
- Follow the instructions to remedy the problem.

To perform the preliminary troubleshooting on an HTR-300, you:

- Compare your voltmeter panel readings at various temperatures against those shown in Figure 3-2.
- Note any voltages that are higher or lower than those in shaded portion of the graph at any temperature.
- Find the symptom and probable cause in Table 3-1.
- Follow the instructions to remedy the problem.

Figure 3-1 and Figure 3-2 are on page 3-2; Table 3-1 is on page 3-3.

The values shown in Figure 3-1 and Figure 3-2 are not exact and are subject to variations caused by ambient temperatures and probe geometries that differ from those used to derive these plots. Nevertheless, they still provide a solid basis for preliminary troubleshooting.

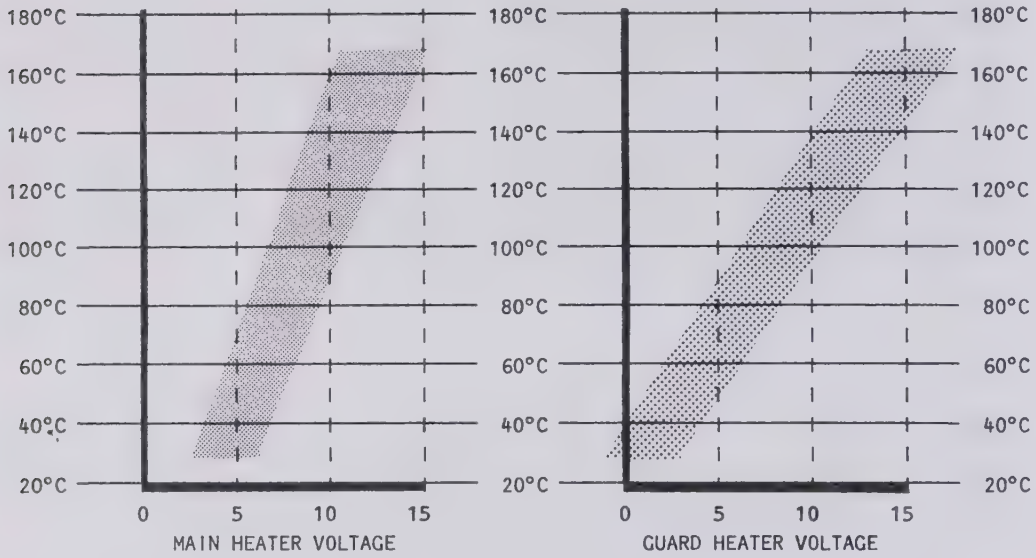

Figure 3-1: HTR-150 Meter Voltages vs Block Temperature

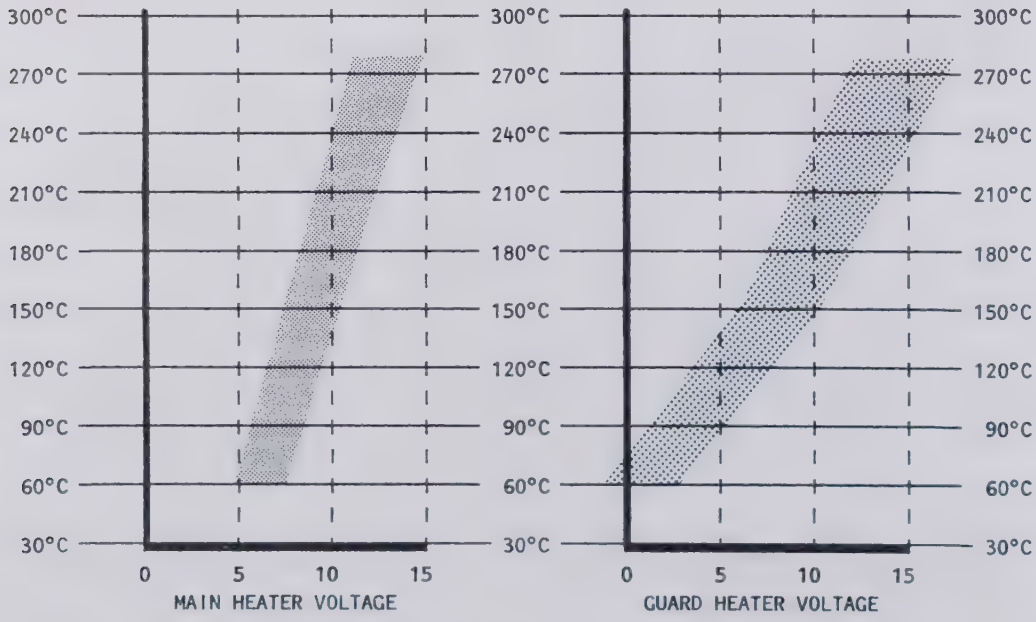

Figure 3-2: HTR-300 Meter Voltages vs Block Temperature

SYMPTOM	PROBABLE CAUSE	SOLUTION
Neither meter shows a voltage.	Power off, blown fuse or defective meters.	Turn power on. Replace the fuse. If this does not work, call Kaye.
Guard heater voltage = zero, but main heater voltage and gross temperature are acceptable.	Inconclusive at low temperature settings. Bottom RTD shorted or top RTD open.	Call Kaye.
Abnormally high guard heater with acceptable main heater voltage and gross temperature.	Bottom RTD open or top RTD shorted.	Call Kaye.
Abnormally high main heater voltage with an uncontrolled temperature rise.	Voltage increases too rapidly by operator or possible shorted RTD in reference block.	Gradually bring up voltage and let temperature settle. If temperature still rises uncontrollably, internal thermostat shuts off HTR. Call Kaye.
Full scale main heater voltage with no heating.	Open heater winding.	Conduct Main Heater Winding test in Internal Resistance Checks section. Call Kaye with results.
Guard heater voltage varies erratically.		Call Kaye.
Mid-range main and guard heater voltages with abnormally high or low temperature.		Call Kaye.

Table 3-1: HTR Troubleshooting Guide

Internal Resistance Checks

As a safety precaution, first unplug the HTR. Then remove the top cover before beginning the internal resistance checks. To access the internal circuits and wiring, remove the two screws on each side of the HTR. Then lift the reference block and top cover assembly off as a unit. Unplug connectors B and C, which connect the reference block to the chassis. You can operate the instrument even after removing the reference block.

If the preliminary checks suggest defective RTD's or heater coils, measure the resistance of each suspected component across the pins indicated in Table 3-2 (page 3-4). Compare that resistance with the normal resistance. Figure 3-3 (page 3-4) identifies connectors B and C. Don't worry about incorrectly connecting the connectors; you can only connect each of the four connectors with its corresponding half.

COMPONENT	CONNECTOR	PIN PAIR	EXPECTED RESISTANCE
Main Heater	B	2 to 5	20 Ω
Bottom Heater	B	3 to 6	20 Ω (HTR-150) 10 Ω (HTR-300)
Guard Heater	B	1 to 4	10 Ω
Block RTD (PRT-3)	C	3 to 6	Varies with block temperature 100 Ω @ 0°C 150 Ω @ 150°C 250 Ω @ 300°C
Bottom Differential RTD (PRT-2)	C	2 to 5	100 Ω to 250 Ω
Guard Block RTD (PRT-1)	C	1 to 4	100 Ω to 250 Ω

Table 3-2: Reference Block Resistance Values

If your HTR has a faulty reference block heater or RTD, return it to Kaye's Bedford facility for servicing. You can replace such parts as the circuit board, transformer, fuse, etc. at your location. Section 4 lists HTR series replacement parts.

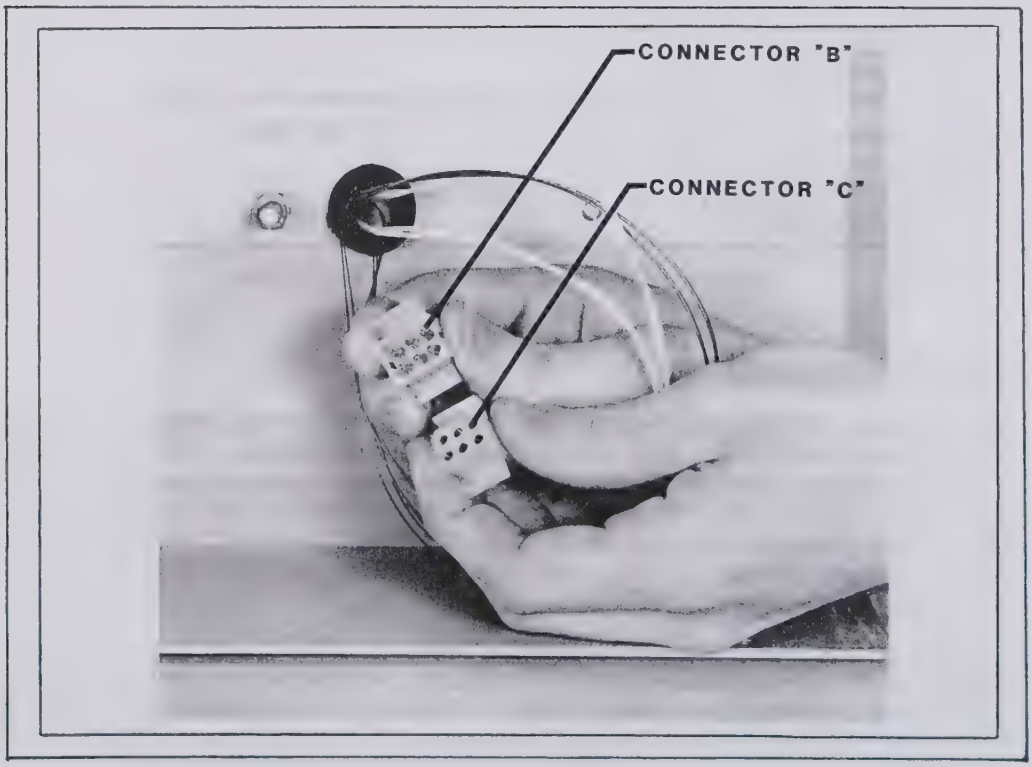

Figure 3-3: Reference Block Connectors

SECTION 4

HTR SERIES REPLACEMENT PARTS LIST

The following list identifies the replacement parts for the HTR series probe calibration reference instruments.

Stock No.	Designation and Description
U0825	Assembled and Tested Printed Circuit Board
V0720	HTR-150 Probe Tube Assembly
V0730	HTR-150 Thermometer Tube Assembly
V0725	HTR-300 Probe Tube Assembly
V0735	HTR-300 Thermometer Tube Assembly
L0110	M1, M2-Meter, 0-30 VDC
F2330	Q1, Q2 Transistor Mounting Kit
T0270	Q1, Q2 Transistor 2N6282
M0069	F1, 2½ amp Slo-Blo Fuse for the 115 VAC HTR-150
M0060	F1, 1 amp Slo-Blo Fuse for the 220 VAC HTR-150
M0080	F1, 3 amp Slo-Blo Fuse for the 115 VAC HTR-300
M0061	F1, 1½ amp Slo-Blo Fuse for the 220 VAC HTR-300
P0146	P1, 100Ω Fine adjustment control
P0145	P2, 100Ω Coarse adjustment control
P0010	P3, 10Ω Differential adjustment control
T0635	T2, T3, T4, DP241-8-28 Transformer

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SECTION 5

HTR SERIES ACCESSORY EQUIPMENT

Kaye Instruments Model 373 RTD Monitor and Models 374 and 375 Platinum RTD's provide highly accurate temperature readouts traceable to NBS standards.

The Model 373 RTD Monitor provides an accurate means for establishing the absolute temperature of calibration blocks and calibration baths. Kaye Instruments designed the instrument for use with up to three platinum resistance temperature detectors (RTD's) which have been calibrated to NBS standards. The RTD provides your line of NBS traceability. The Model 373 RTD Monitor incorporates:

- An NBS-traceable standard resistor.
- An accurate constant current source.
- A stable digital voltmeter.
- A switching system.

The digital resistance readouts are accurate to 0.01 ohms.

Kaye offers two models of calibrated RTD's: the Model 374 Platinum RTD and the Model 375 Platinum RTD. The Model 374 Platinum RTD (a 4-wire RTD) has a range of 0°C to 130°C with a base resistance of 100 ohms at 0°C. When used with the RTD Monitor, the Model 374 Platinum RTD achieves calibrations accurate to ±0.05°C.

The Model 375 Platinum RTD has a range of 0°C to 350°C with a base resistance of 50 ohms at 0°C. When used with the RTD Monitor, the Model 375 Platinum RTD achieves calibrations accurate to ±0.15°C.

Appendix C contains a detailed error summary for the Kaye Model 374 and Model 375 Platinum Resistance Thermometers as well as the Kaye Model 373 RTD Monitor.

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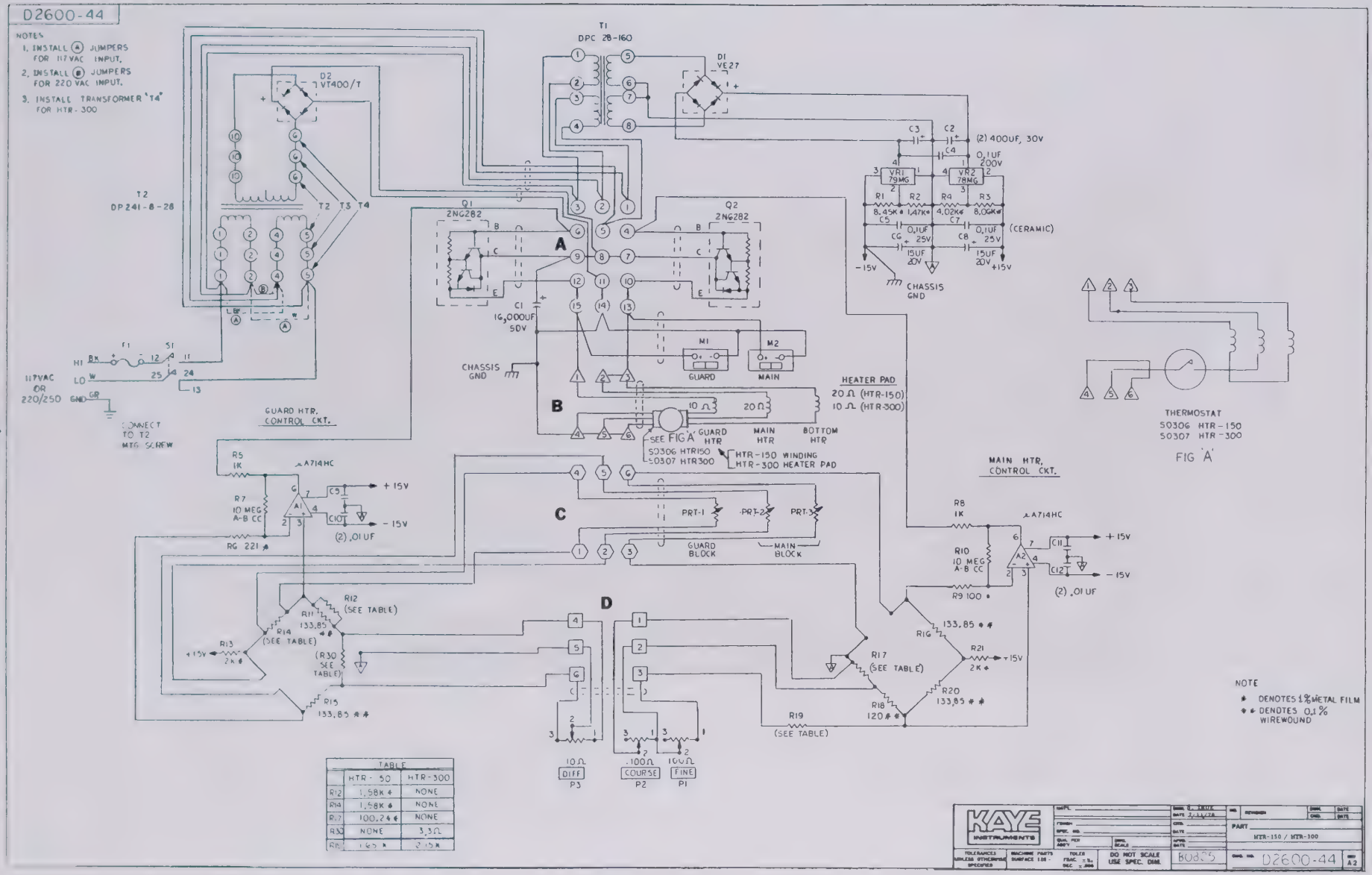

A-1

APPENDIX A

HTR-150/HTR-300 SCHEMATICS

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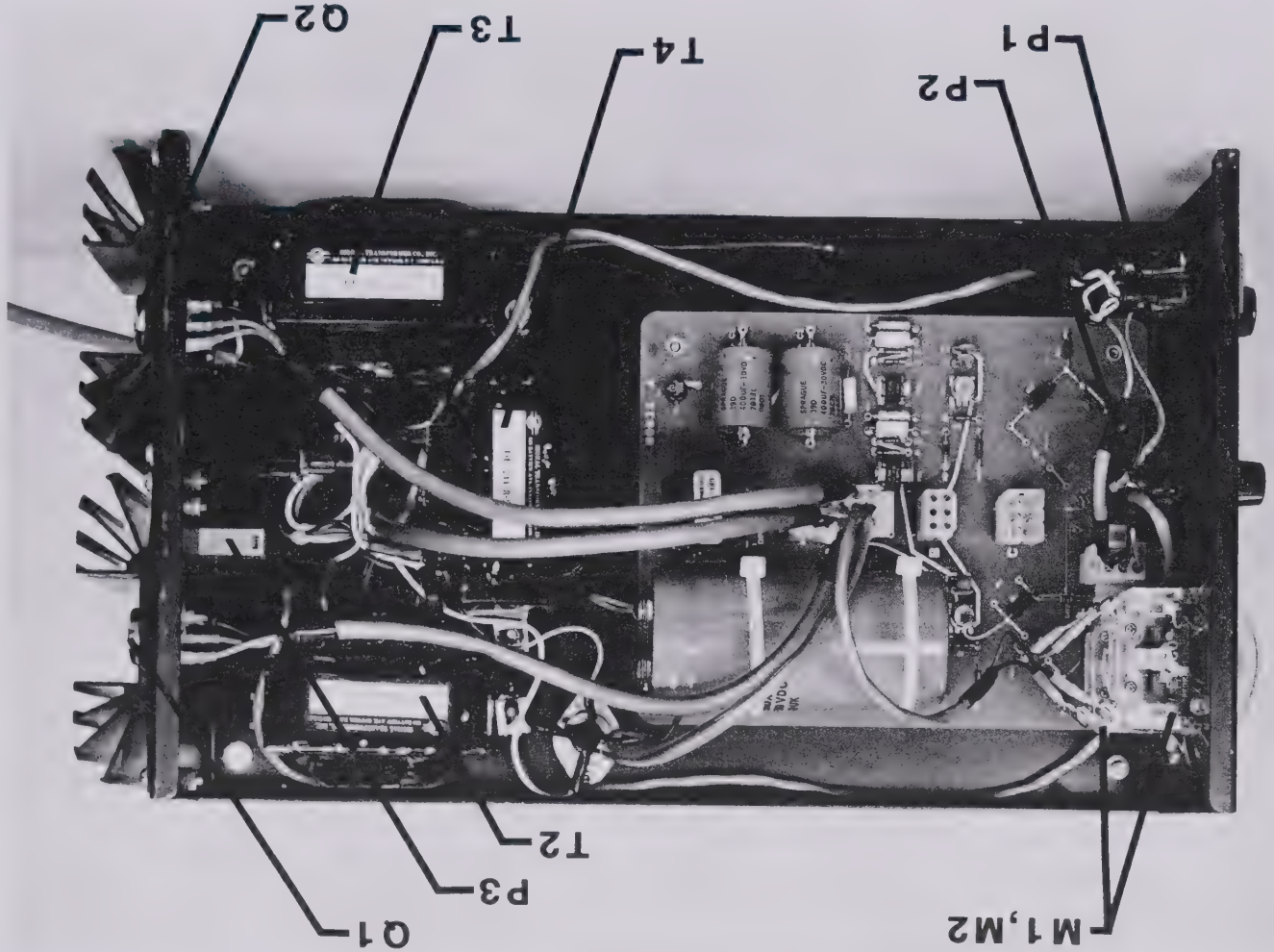

APPENDIX B

HTR-150/HTR-300 COMPONENT LAYOUT

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APPENDIX C

Model 374 Platinum RTD Error Summary

Accuracy in °C For Range:

	0°C to 130°C
Kaye Accuracy Standards	±.01
Temperature Transfer Error	±.01
Resistance Transfer Error (Temp. Eq.)	±.01
Accuracy at Cal Point	±.03
Accuracy Over Range	±.04

User's Error Analysis

	0°C to 130°C
Model 374 Calibration Accuracy[1]	±.04
Model 373 Calibration Accuracy[1]	±.05
HTR-150 or HTR-300 Error, Similar Probe[2]	±.01
User's Error With Similar Probe	±.10
HTR-150 or HTR-300 Error, Dissimilar Probe[3]	±.10
User's Error, Dissimilar Probe	±.19

Model 375 Platinum RTD Error Summary

Accuracy in °C For Ranges:

	0-100°C	100-200°C	200-300°C
Kaye Accuracy Standards	±.01	±.05	±.10
Temperature Transfer Error	±.02	±.03	±.04
Resistance Transfer Error (Temp. Eq.)	±.02	±.02	±.02
Accuracy at Calibration Point	±.05	±.10	±.16
Accuracy Over Range	±.07	±.13	±.20

User's Error Analysis

	0-100°C	100-200°C	200-300°C
Model 375 Cal. Accuracy[1]	±.07	±.13	±.20
Model 373 Cal. Accuracy[1]	±.10	±.10	±.10
HTR-300 Error, Similar Probe[2]	±.02	±.03	±.04
User's Error, Similar Probe	±.19	±.26	±.34
HTR-300 Error, Dissimilar Probe[3]	±.10	±.15	±.20
User's Error, Dissimilar Probe	±.27	±.38	±.50

1 Assumes zero and span checks made.

2 Assumes thermal response characteristics of unknown sensors similar to 374 or 375. Full depth immersion.

3 Assumes thermal response characteristics of unknown sensors very different from 374 or 375, i.e. fine wire thermocouples or large diameter RTD. Full depth immersion.

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APPENDIX D

KAYE INSTRUMENTS, INC.
EQUIPMENT LIMITED WARRANTY

TO WHOM GIVEN:

Kaye Instruments, Inc. ("Kaye") extends this warranty only to the original non-consumer purchaser of its equipment; IT DOES NOT EXTEND TO CONSUMER PURCHASERS FOR PERSONAL, FAMILY OR HOUSEHOLD PURPOSES.

COVERAGE AND LENGTH OF WARRANTY:

1. New Equipment:: All new Kaye equipment, except thermocouples and RTD probes, is warranted to be free from manufacturing and material defects for a period of one (1) year after shipment.

2. Thermocouples, RTD Probes, Spare Parts and Repairs: New Kaye thermocouples and RTD probes, and Kaye spare parts for and repairs to Kaye equipment are warranted to be free from manufacturing and material defects for a period of ninety (90) days after shipment.

3. Non-Standard Kaye Products: Equipment provided by Kaye, together with a Kaye system, but which are not standard Kaye products (e.g. magnetic tape recorders, paper tape punches and computers), are warranted by Kaye for a period of thirty (30) days after shipment. If the manufacturer of such equipment provides a longer warranty, Kaye will, if possible, pass this warranty on to its customers.

4. Modifications: Modifications to Kaye equipment performed by authorized Kaye service representatives that increase the performance or capability of that equipment are warranted free from manufacturing and material defects for the following period:

   a. Six (6) months from the date of shipment, or the balance of the original new equipment warranty, whichever is longer, for modifications performed at the Kaye Instruments Factory Service Center in Bedford, Massachusetts.

   b. Ninety (90) days from the date of shipment, or the balance of the original new equipment warranty, whichever is longer, for modifications performed at any other location.

WARRANTY PROCEDURES:

1. What Kaye Will Do: Any equipment or spare parts purchased from Kaye that become defective during the relevant period, or repairs or modifications done by authorized Kaye service representatives that fail during the relevant period, will be repaired or replaced at the customer's site or at the Kaye Instruments plant in Bedford, Massachusetts, at Kaye's option.

2. Procedure for Claims: If a customer believes a defect has occurred under this warranty, the customer should contact the Kaye Instruments Customer Service Department, which will provide instructions as to the procedure to be followed. Return authorization must be obtained from the Customer Service Department prior to returning any equipment for repair. Equipment returned to Kaye for repair must have shipping charges prepaid and must be accompanied by documentation explaining the reason for repair. Any repairs performed by Kaye with respect to defects not covered by this warranty will be subject to time and materials charges at Kaye's standard rates.

DISCLAIMER:

1. Misuse of Products: This warranty is void if the product has been damaged by accident, unreasonable use, negligence, intentional harm, improper assembly or has been subject to unusual physical or electrical stress or has been modified without Kaye's approval.

2. LIMITATION OF OTHER WARRANTIES; LIMITATION OF LIABILITY:
THE EQUIPMENT LIMITED WARRANTY SET FORTH HEREIN IS EXCLUSIVE AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE. STATEMENTS CONTAINED IN ANY KAYE LITERATURE, AND ANYTHING THAT ANY KAYE EMPLOYEE, REPRESENTATIVE OR DEALER MAY HAVE REPRESENTED TO YOU DO NOT CONSTITUTE A WARRANTY BY KAYE. ALL LIABILITIES OR OBLIGATIONS OF KAYE FOR DAMAGES OCCURRING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF KAYE PRODUCTS ARE LIMITED TO THOSE CONTAINED IN THIS WARRANTY, AND KAYE SHALL NOT BE LIABLE FOR ANY OTHER DAMAGES OR EXPENSES, INCLUDING CONSEQUENTIAL OR INCIDENTAL DAMAGES.

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